Report for 2002SD7B: Survey of the Macrophyte and Invertebrate Communities in Enemy Swim and Pickerel Lakes

There are no reported publications resulting from this project.

Report Follows:

Introduction

The purpose of this study was to describe the macro invertebrate fauna, the aquatic macrophyte community and current trophic state of two relatively rare lake habitats in South Dakota. The potential for exotic species such as zebra mussels, eurasian water milfoil and the rusty crayfish to negatively impact the native fauna in these lakes was a concern.

Introduced exotic species could have a severe impact on native flora and fauna in these lakes. In 1986, a ship released ballast water into Lake St. Clair, Michigan and introduced the zebra mussel. This organism can kill native clams and competes with larval fish and other aquatic organisms for food. The zebra mussel has spread throughout the Great Lakes and has been found in the Mississippi and Minnesota Rivers. If this exotic species is introduced into Enemy Swim and Pickerel Lakes it is expected to have a large impact on the ecological balance.

A second exotic species, Eurasian water milfoil, has already been introduced to Lake Sharp in South Dakota. Milfoil is a fast growing aquatic weed that crowds out native plants and forms dense mats in shallow water. This plant can reproduce from a single fragment and is easily carried from lake to lake on boats and trailers. Fishermen traveling from Minnesota to fish in South Dakota waters may eventually introduce zebra mussels and/or milfoil to these habitats. South Dakota fishermen traveling to the Missouri River or out-of-state lakes are also potential carriers of exotics back to South Dakota
If invasion by exotic species does occur, data from this study would allow future managers set goals for reestablishing a more natural ecosystem and mitigate the impacts of the exotic species. Data presented in this summary report include surveys and sampling conducted in both 2002 and 2003.

Objectives

The objectives of this research were to:

1). To prepare a list of aquatic macro-invertebrates and their relative abundance for all major habitats in Enemy Swim and Pickerel Lakes.

2). To prepare a list of aquatic plants and their general distribution in both lakes.

3). To assess the current trophic state of the lakes by monitoring selected water quality parameters.

Lake Description

Enemy Swim is natural glacial lake located in northeast Day County about eight miles north of the town of Waubay, South Dakota. The lake covers approximately 2,146 acres and has a 22,310-acre watershed located mostly in Roberts County. The lake is not deep enough to form a thermally stratified system in most years (German, 1997). Most natural lakes in South Dakota are simple basins, but Enemy Swim has been described by Game, Fish and Parks Fisheries personnel as a "complex lake basin with highly variable substrate including rock, boulders, gravel, cobble, sand, etc." The varied habitat accounts for a diverse population of fish, twenty-one species have been reported in Enemy Swim Lake.

Pickerel Lake is also a natural glacial lake located in northeastern Day County about ten miles north of the town of Waubay, South Dakota. The lake covers approximately 955 acres to an average depth of 22 feet, and a maximum depth of 43 feet. The lake bottom is predominately rubble with scattered areas of sand and gravel. Silt and organic clay are found in the bays and deeper areas of the lake. Haworth (1972) reported that the north bay of the lake contains 24 feet of sediment, which has accumulated over the 12,000 years since the lake was formed. The lake is deep enough to thermally stratify during the summer months (Day Conservation District, 1991, German,1996).

Pickerel lake is the deepest natural lake in South Dakota and also has a highly variable substrate with many of the same characteristics as Enemy Swim. The main difference between the lakes is Enemy Swim has an extensive system of shallow bays whereas Pickerel lake has fewer bays and much more deep water habitat.

Enemy Swim and Pickerel Lakes are mesotrophic to lower eutrophic which represents a relatively rare habitat in South Dakota. Most natural lakes are eutrophic to hypereutrophic and many have been identified as impaired because they are not meeting their designated beneficial uses. The State of South Dakota has assigned the following beneficial uses to both Enemy Swim and Pickerel Lakes:

- Warm water permanent fish life propagation
- Limited contact recreation
- Immersion recreation; and
- Wildlife propagation and stock watering

Methodology

Objective 1: Aquatic macro-invertebrates

Shoreline habitats sampled for macro-invertebrates included rocky/rubble, sand/gravel, and muddy vegetation and were sampled at several locations. Mid-lake samples were collected in several locations to describe deeper water habitats. Samples were collected by a variety of methods including the use of Eckman dredges and a Wildco Biological Dredge. Manual collection of organisms by D-frame dip net and picking organisms from rocks, plants, and submerged wood was also conducted. Snorkeling and scuba gear was used to collect clams in deeper waters. A photographic history of many organisms collected was also kept and will be expanded in 2004. Hester Dendy samplers will be placed in several shoreline locations to gather quantitative data on macro-invertebrate populations in 2004. (EPA, 1990 and APHA, 1985).

Students participating in the “Lakes Are Cool” program collected additional macro-invertebrate samples using a variety of methods including examination of submerged wood, rocks, vegetation, detritus examined in white pans or wash buckets. Participation by the students increased the number of macro-invertebrates collected especially the more rare forms like fishfly larvae and water scorpions..

Objective 2: Aquatic macrophytes

Plants were collected by wading in shallow water and by snorkeling. All sampling locations were recorded using a portable GPS unit. Aquatic plant identifications were verified by Dr. Gary Larson at SDSU. Several specimens were pressed and added to the SDSU Herbarium collection under the direction of Dr. Gary Larson.

Objective 3: Trophic State

Trophic state was assessed by using the same water quality monitoring methods used during the Lake Protection study in 1991-1995 (German,1997). In-lake water quality samples were collected with a Van Dorn-type water sampler from three mid lake stations using a boat. A composite surface sample for the lake was formed by mixing equal amounts of water from each site. A composite near bottom sample was formed by mixing water collected near the bottom from each of the three sites in each lake. Parameters analyzed on lake samples included:

1. Total phosphorus
2. Total dissolved phosphorus
3. Organic nitrogen
4. Ammonia
5. Nitrate + nitrite
6. Suspended solids
7. pH
8. Air and water temperature
9. Dissolved oxygen
10. Secchi depth
11. Chlorophyll a (surface samples only)
12. Fecal coliform bac (surface samples only)

Water sampling was conducted at Enemy Swim Lake in mid June, July and August in 2002 and 2003. Sampling was conducted at Pickerel Lake in mid May, June, July and August and September in 2002 and 2003. Dennis Skadsen from the Day Conservation District, the Pickerel Lake Sanitary District, and the Enemy Swim Lake Sanitary District contributed to this effort

Results

Objective 1: Aquatic macro-invertebrates

The invertebrate fauna in both lakes is more diverse than was expected based on published studies of the invertebrate fauna in other South Dakota lakes.(Benson and Hudson 1975, Boehmer et. al. 1975,Donaldson 1979, Gengerke and Nickum 1972, German 1978, Hartung 1968, Hudson 1970, Schmulbach and Sandholm 1962, Smith 1971,Wolf and Goeden 1973). The presence of fishflies and stoneflies was particularly surprising because they had not been reported from this area of South Dakota prior to this study. Johnson (1997). first reported the presence of fishflies in South Dakota based on larvae collected in Lacreek refuge. The first adults reported in the state were collected during this project at both Enemy Swim and Pickerel Lakes in 2002. These specimens have been deposited in the Insect Research Collection at SDSU. Insects comprised the largest portion of the invertebrate fauna. The list of macro-invertebrates collected and identified so far at Enemy Swim and Pickerel Lakes is presented in Table 1. The list includes both adults and immature stages collected at both lakes. This list is a work in-progress. Additional work will be needed to complete the list, especially for the damselflies, beetles, dipteras, and caddisflies.

Insects

Order	Family	Genus/Species	Common Name
Ephemeroptera			
	Ephemeridae	*Hexagenia* sp.	
	Heptageniidae	*Stenonema* sp.	
Odonata			
	Aeshnidae		
		Anax junius	Common green darner
		Aeshna constricta	Lance-tipped darner
		Aeshna interrupta	Variable darner
	Corduliidae		
		Epitheca cynosura	Common basketail
	Limbellulidae		
		Libellula luctuosa	Widow skimmer
		Libellula Lydia	Common whitetail
		Libellula pulchella	Twelve-spotted skimmer
		Libellula quadrimaculata	Four-spotted skimmer
		Sympetrum costiferum	Saffron-winged meadowhawk
		Sympetrum internum	Cherry-faced meadowhawk
		Sympetrum rubincundulum	Ruby meadowhawk
		Sympetrum obtrusum	White-faced meadowhawk
		Sympetrum corruptum	Variegated meadowhawk

Order	Family	Genus/Species	Common Name
Odonata (cont.)	Limbellulidae (cont.)	*Perithemis tenera*	Eastern amberwing
		Pachydiplax longipennis	Blue dasher
		Erythemis simplicicollis	Eastern pondhawk
		Tramea lacerata	Black saddlebags
		Tramea onusta	Red saddlebags
		Leucorrhinia intacta	Dot-tailed whiteface
		Celithemis eponina	Halloween pennant
		Celithemis elisa	Calico pennant
	Coenagrionidae		Pond Damsels
Trichoptera			
	Helicopsychidae	*Helico borealis*	Snail shell caddisfly
	Hydropsychidae		
	Hydroptilidae		Micro caddisfly
Megaloptera			
	Corydalidae	*Chauliodes rastricornis*	Fishfly
Hemiptera			
	Belostomatidae	*Belostoma* sp.	Small giant water bug
	Corixidae		Water boatman
	Nepidae	*Nepa apiculata*	Water scorpion
	Notonectidae		Back swimmers
	Gerridae		Water strider

Order	Family	Genus/Species	Common Name
Coleoptera			
	Gyrinidae		Whirligig beetles
Diptera			
	Ceratopogonidae		Noseeums
	Chironomidae	Numerous species	Midges
	Culicidae		Mosquitoes
	Chaoboridae	*Chaoborus* sp.	Phantom midge

Crustacea

Order	Family	Genus	Common Name
Amphipoda			
	Gammaridae		Scuds
Decapoda			
	Cambaridae	*Orconectes virilis*	Northern crayfish
		Orconectes immunis	Calico crayfish
		Unidentified Species	

Snails

Order	Family	Genus	Common Name
Lymnophila			
	Physidae		Tadpole snails
	Lymnaeidae		Pond snails

Clams

Order	Family	Genus	Common Name
Pelecypoda			
	Unionidae	*Lampsilis*	Fat mucket
		Anodonta grandis	Giant floater

Hirudinea (leeches)

Order	Family	Genus	Common Name

Objective 2: Aquatic macrophytes

The list of macrophytes collected and identified so far at Enemy Swim and Pickerel Lakes is presented in Table 2. No new records of aquatic macrophytes for the state or for the area were recorded. There was no evidence of Eurasian water milfoil in either lake.

Table 2. Macrophytes collected at Enemy Swim and Pickerel Lakes

Common Name	Scientific Name
Water plantain	Alisma gramineum
Coontail	Ceratophyllum demersum
Needle spikesedge	Eleocharis acicularis
Spikerush	Eleocharis erythropoda
Mare's-tail	Hippuris vulgaris
Water milfoil	Myriophyllum sibiricum
Naid	Najas flexilis
pondweed	Potamogeton friesii
Variable pondweed	Potamogeton gramineus
Illinois pondweed	Potamogeton illinoensis
Floatingleaf pondweed	Potamogeton natans
Sago pondweed	Potamogeton pectinatus
Whitestem pondweed	Potamogeton praelongus
Claspingleaf pondweed	Potamogeton richardsonii
Flatstem pondweed	Potamogeton zosteriformis
Widgeon-grass	Ruppia cirrhosa
Arrowhead	Sagittaria latifolia
Hardstem bulrush	Schoenoplectus acutus
River bulrush	Schoenoplectus fluviatilis
Common bladderwort	Utricularia vulgaris
Water stargrass	Zosterella dubia

Objective 3: Trophic State

Water quality data collected for Enemy Swim Lake in 2002 and 2003 is presented in table 3. Water quality data collected for Pickerel Lake in 2002 and 2003 is presented in tables 4 and 5 respectively.
Trophic state is a way of describing how productive or enriched a lake is compared to other lakes. Lakes range from nutrient poor (oligotrophic), to moderately rich (mesotrophic), to highly enriched (eutrophic), to excessively enriched (hypereutrophic). Pickerel Lake and Enemy Swim Lake exhibited characteristics of lakes that are described as mesotrophic to early eutrophic in 2002 and 2003 (Tables 3, 4 and 5).

Table 3 . Water quality values from Enemy Swim in 2002-03.

Parameter	Unit	2002						2003					
		June 6/15/02		July 7/16/02		August 8/16/02		June 6/17/03		July 7/13/03		August 8/16/03	
Air Temperature	°C					17.0							
Transparency	ft	14.5		6.9		5.9		7.8		6.3		5.4	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Water Temperature	°C	19.5	18.4	24.2	23.9	21.3	21.3	23.8	17.1	22.6	22.6	24.0	23.5
Dissolved Oxygen	mg/L	10.9	10.4	8.3	7.4	8.4	8.0	8.6	7.1	7.7	7.7	10.5	8.4
pH	--	8.90	8.92	8.74	8.63	8.52	8.86	8.85	8.78	8.72	8.58	8.76	8.66
Suspended Solids	mg/L	3.0	3.0	4.5	5.8	7.6	10.0	3.3	12.5	6.7	8.0	5.7	8.0
Total Kjeldahl N	mg/L	0.65	0.65	0.74	0.78	0.84	0.81	0.78	0.92	0.80	0.92	1.27	1.07
Organic N	mg/L	0.65	0.63	0.74	0.74	0.79	0.75	0.72	0.87	0.75	0.83	0.70	0.83
Nitrate (NO_3)	mg/L	0.044	0.060	0.020	0.000	0.074	0.074	0.024	0.024	0.010	0.011	0.042	0.042
Ammonia (NH_3)	mg/L	0.01	0.02	0.00	0.02	0.05	0.06	0.04	0.05	0.05	0.09	0.04	0.03
Total Phosphorus	mg/L	0.025	0.027	0.025	0.026	0.033	0.032	0.014	0.032	0.020	0.041	0.032	0.027
Total Dissolved P	mg/L	0.039	0.030	0.002	0.000	0.003	0.010	0.002	0.011	0.017	0.015	0.014	0.006

Table 4 Water quality values from Pickerel Lake in 2002.

Parameter	Unit	May 5/19/02		June 6/15/02		July 7/16/02		August 8/16/02		September 9/16/02	
Air Temperature	°C	10.4		17.3		22.0		17.0		25.0	
Transparency	ft	5.2		6.7		6.1		4.3		4.0	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Water Temperature	°C	11.6	11.1	19.2	17.7	24.5	22.3	21.7	21.3	20.5	19.3
Dissolved Oxygen	mg/L	10.8	10.2	10.0	6.2	8.5	1.3	8.5	8.1	9.9	7.9
pH	--	9.10	9.03	8.89	8.77	8.79	8.43	7.90	8.38	9.00	8.90
Suspended Solids	mg/L	10.0	14.5	6.0	15.0	9.0	10.5	10.7	14.0	9.8	17.3
Total Kjeldahl N	mg/L	0.80	0.84	1.25	1.08	0.88	1.31	1.32	1.05	1.14	1.22
Organic N	mg/L	0.77	0.82	1.24	1.02	0.81	0.93	1.23	0.95	1.04	1.10
Nitrate (NO_3)	mg/L	0.042	0.046	0.052	0.046	0.030	0.028	0.080	0.076	0.012	0.012
Ammonia (NH_3)	mg/L	0.03	0.02	0.01	0.06	0.07	0.38	0.10	0.10	0.10	0.13
Total Phosphorus	mg/L	0.043	0.054	0.038	0.070	0.025	0.036	0.040	0.047	0.048	0.060
Total Dissolved P	mg/L	0.008	0.007	0.020	0.016	0.004	0.011	0.013	0.013	0.016	0.019

Table 5. Water quality values from Pickerel Lake in 2003.

Parameter	Unit	May 5/28/03		June 6/17/03		July 7/13/03		August 08/16/03		September 09/14/03	
Air Temperature	°C	57.0								42.0	
Transparency	ft	4.2		6.6		5.9		3.7		3.1	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Water Temperature	°C	14.1	12.7	22.7	16.9	22.3	22.0	24.1	23.0	18.4	18.4
Dissolved Oxygen	mg/L	9.9	9.5	9.6	3.2	7.2	2.7	8.7	4.4	8.9	8.9
pH	--	8.58	8.56	8.74	8.33	8.56	8.33	8.66	8.40	8.65	8.64
Suspended Solids	mg/L	12.0	24.0	5.3	5.7	6.3	13.0	10.0	12.7	12.0	12.0
Total Kjeldahl N	mg/L	1.20	1.02	0.91	0.92	1.40	1.19	1.27	1.07	1.70	1.39
Organic N	mg/L	1.11	0.94	0.84	0.82	1.29	0.96	1.23	1.04	1.44	1.13
Nitrate (NO_3)	mg/L	0.025	0.025	0.025	0.024	0.012	0.012	0.043	0.042	0.042	0.044
Ammonia (NH_3)	mg/L	0.08	0.08	0.07	0.10	0.11	0.23	0.03	0.04	0.27	0.26
Total Phosphorus	mg/L	0.034	0.070	0.034	0.033	0.041	0.082	0.046	0.099	0.067	0.071
Total Dissolved P	mg/L	0.010	0.030	0.005	0.012	0.003	0.020	0.014	0.025	0.020	0.018

Transparency

The transparency of lake water is important to the aesthetic value of a lake. In most lakes, water transparency is determined by variations in suspended sediment or algal populations. It is used as an indirect indicator of algal populations in lakes without significant suspended sediment. In reservoir systems, transparency may be a function of sediment load or turbidity. Most of the time water transparencys in Pickerel and Enemy Swim Lakes are a function of algal populations. Transparency in Enemy Swim Lake ranged from 14.5 feet in June 2002 to 5.4 feet in August 2003 (Table 3). Transparency in Pickerel Lake ranged from 6.7 feet in June 2002 (Table 4) to 3.1 feet in August 2003 (Table 5). Transparencies in this range are common in mesotrophic to eutrophic lakes.

Suspended Solids

Low suspended solids concentrations are desirable in lakes for aesthetic reasons and for maintenance of a heathy fishery. Fish populations can be affected by high suspended solids in several ways. fish can be killed directly or their growth, resistance to disease and reproduction success may be reduced. Migrations can also be affected (EPA, 1976). High suspended solids concentrations result in reduced aesthetic value of a lake which can limit recreational use. The state standard for maintaining a warm water permanent fishery is 90 mg/l. This standard was not exceeded on any of the sampling dates reported for either lake (Tables 3, 4 and 5).

Phosphorus

Phosphorus is required for the growth of all forms of algae, but relatively small quantities are needed. If other nutrients are available, one pound of phosphorus can produce 500 pounds of algae (Wetzel, 1983). It is often the nutrient that limits the growth of algal populations. It is therefore also the nutrient that must be controlled in order to maintain good water quality. Total phosphorus concentrations for Enemy Swim Lake surface samples ranged from .014 mg/l on 6/17/03 to .033 mg/l on 8/16/03 (Table 3). Total phosphorus concentrations for Pickerel Lake surface samples ranged from .025 mg/l on 7/16/02 to .067 mg/l on 9/14/03 (Tables 4&5). Using phosphorus as a trophic state index, a concentration of .03 mg/l value represents the border between mesotrophic and eutrophic lakes. A concentration of .03 to .1 mg/l would be classified as eutrophic (Wetzel, 1983). Total phosphorus concentrations in this range are common in mesotrophic to eutrophic lakes.

Dissolved phosphorus is the most available form for use by algae and other plants. It is rapidly consumed by algae and seldom reaches high concentrations in surface waters unless other factors are limiting algal growth. Dissolved phosphorus enters lakes from runoff but it is also released from sediments into the water under anoxic conditions (oxygen levels near zero). In both 2002 and 2003 slightly higher concentrations of dissolved phosphorus in bottom waters compared to surface waters were observed in Pickerel Lake (Tables 4 & 5). Pickerel lake was weakly stratified and oxygen concentrations were lower in deeper waters compared to surface waters in July and July of both years (Tables 4& 5). This probably contributed to the release of phosphorus from the sediments in Pickerel Lake. In Enemy Swim Lake concentrations of oxygen and dissolved phosphorus in surface samples was essentially the same as bottom waters in 2002 and 2003 (Table 3).

Nitrogen

Nitrogen is present in lakes in several forms, both inorganic and organic. The inorganic forms (ammonia, nitrite and nitrate) are important nutrients available for plant growth. Organic nitrogen represents nitrogen incorporated into living (or once living) material and can be used to define trophic state. Wetzel, (1983) reports that mesotrophic lakes worldwide generally range from .4 to .7 mg/l and eutrophic lakes have up to 1.2 mg/l of organic N. Organic N concentrations in Pickerel Lake ranged from 0.77 mg/l on 5/19/02 (Table 4) to 1.44 mg/l on 9/14/03 (Table 5) indicating eutrophic conditions. The median concentration of organic nitrogen in Pickerel Lake from 1991 to 1995 was .62 mg/l which represents mesotrophic conditions (German, 1997). This indicates a possible increase in productivity in the lake and a move toward more eutrophic conditions based on organic nitrogen. Organic N concentrations in Enemy Swim surface samples ranged from 0.65 mg/l on 6/15/02 (Table 5) to 0.79 mg/l on 8/16/02 (Table 5). The median concentration of organic nitrogen in Enemy Swim surface samples from 1991 to 1995 was .68 mg/l which represents mesotrophic conditions (German, 1997).

Ammonia is generated as an end product of bacterial decomposition of dead plants and animals and is also a major excretory product of aquatic animals. Ammonia is directly available for plant growth and is the most easily used form of nitrogen. It can support the rapid development of algal blooms if other nutrients are present. Ammonia concentrations in Pickerel Lake surface samples ranged from 0.01 mg/l on 6/15/02 (Table 4) to 0.27 mg/l on 9/14/03 (Table 5). Ammonia concentrations in Pickerel lake surface samples ranged from below the detection limit to .15 mg/l with a median value of .01 mg/l in the period from 1991 to 1995 (German, 1997). Ammonia concentrations in Enemy Swim surface samples ranged from below the detection limit on 7/16/02 to 0.05 mg/l on 7/13/03 (Table 5).

Dissolved Oxygen

Adequate dissolved oxygen is necessary to maintain a healthy lake. Lakes with good oxygen concentrations throughout the year are more likely to have a diverse population of aquatic organisms rather than one that is dominated by a few hardy species. Low oxygen concentrations are detrimental to populations of many organisms and usually reduces diversity and stability in a lake ecosystem. .

Oxygen concentrations can also affect other chemical parameters in lakes. For example, when anoxic conditions form at the bottom of a lake, dissolved phosphorus, ammonia, and hydrogen sulfide and other undesirable substances are released from the lake sediments into the water column. These nutrients can contribute to algal growth when lakes turn over. Ammonia and hydrogen sulfide may also be toxic to aquatic organisms if they are present in sufficient concentrations.

Oxygen concentrations in Pickerel Lake and Enemy Swim Lake surface samples were consistently above the state standard of 5.0 mg/l in 2002 and 2003. This was also true of the 1991-1995 period as well (German, 1997). Weak thermal stratification and depressed oxygen concentrations were observed in Pickerel Lake in both 2002 and 2003. From 1991 to 1995 oxygen concentrations less than 5 mg/l were observed near the lake bottom on 10 of 15 sampling dates (German, 1997).

Overall the health of Pickerel Lake and Enemy Swim is good although they may be drifting to a more eutrophic condition. Collecting additional data in the next few years will help determine if this is normal year to year variation or a true trend. A large amount of construction has occurred around the shoreline in recent years especially on Pickerel Lake and land in CRP has been put back into production, which can cause more nutrients to enter the lake. Installation of the sewer system on Pickerel Lake has probably helped reduce nutrients from septic tanks but other measures to control nutrients from construction, farming and lawn care should be considered.

Youth Education

The scope of the project includes the participation of several local agencies. Dennis Skadsen of the Day Conservation District initiated an educational program called "Lakes Are Cool" to educate youth in the watershed about the importace of keeping lakes clean. The project involves teachers and students from local schools that participated in the "Lakes Are Cool" program that was held in 2002 and 2003 as part of the Enemy Swim Lake Watershed Improvement Project. This EPA funded watershed project sponsored by the Day Conservation District allowed local students to participate in the collection and identification of aquatic macro-invertebrates.

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